

## Verification of Translation

I, Shuji Sawada of 2-34-1710, Heso 2-chome, Ritto-cho, Kurita-gun, Shiga 520-3031 JAPAN, state that

1. I am familiar with the Japanese and English languages.
2. I have read the attached translation into Japanese Patent Application No. HEI9-172354 filed on June 27, 1997 and the attached translation is a accurate translation of the Japanese-language original document.

Executed at Otsu-shi, Shiga-ken this 17th day of March, 2000.

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[Title of the invention] A method for producing a plasma display panel

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[Title of the invention] A method for producing a plasma display panel

[Claims]

[Claim 1] A method for producing a plasma display panel, in which a glass substrate is coated with three fluorescent pastes respectively containing a fluorescent powder emitting light of red, green or blue discharged from a paste applicator with outlet holes, in stripes on the spaces between the respectively adjacent partitions formed on the substrate, and the pastes are burned to form a fluorescent face, characterized in that the number of outlet holes per paste applicator is in a range of  $16n$  (where  $n$  is a natural number)  $\pm 5$ .

[Claim 2] A method for producing a plasma display panel, according to claim 1, wherein the outlet holes are nozzles or needles.

[Claim 3] A method for producing a plasma display panel, according to claim 1 or 2, wherein the outlet holes and/or the glass substrate is driven to travel in parallel to the partitions formed on the glass substrate.

[Claim 4] A method for producing a plasma display panel, according to any one of claims 1 through 3, wherein the distance between the tips of the outlet holes and the tops of the partitions during coating is 0.01 to 2 mm.

[Claim 5] A method for producing a plasma display panel, according to any one of claims 1 through 4, wherein the number of the outlet holes for coating per stripe is 2 or more.

[Claim 6] A method for producing a plasma display panel, according to any one of claims 1 through 5, wherein each paste applicator has outlet holes for discharging two or more fluorescent pastes different in the color of emitted light, and the shortest distance between the outlet holes for discharging fluorescent pastes different in color is 600  $\mu\text{m}$  or more.

[Claim 7] A method for producing a plasma display panel, according to any one of claims 1 through 6, fluorescent pastes are discharged simultaneously from two or more paste applicators capable of being controlled in position respectively independently, for simultaneously coating respectively different spaces formed between adjacent partitions on the same substrate.

[Claim 8] A method for producing a plasma display panel, according to claim 7, wherein the two or more paste applicators are driven to travel at the same speed for coating.

[Claim 9] A method for producing a plasma display panel, according to claim 8, wherein the two or more paste applicators are driven to travel in the same direction at the same speed for coating.

[Claim 10] A method for producing a plasma display panel, according to any one of claims 7 through 9, wherein one paste applicator is used for coating of one color only.

[Claim 11] A method for producing a plasma display panel, according to any one of claims 7 through 10, wherein the fluorescent paste of one color is simultaneously discharged from two or more paste applicators capable of being controlled in position respectively independently.

[Claim 12] A method for producing a plasma display panel, according to any one of claims 7 through 11, wherein the positions of the outlet holes of the two or more paste applicators are apart from each other in the direction perpendicular to the partitions by integer times each of the partition intervals.

[Claim 13] A method for producing a plasma display panel, according to any one of claims 7 through 12, wherein respectively adjacent two paste applicators are apart from each other in the direction parallel to the partitions.

[Claim 14] A method for producing a plasma display panel, according to any one of claims 1 through 13, wherein coating of each color is followed by drying.

[Claim 15] A method for producing a plasma display panel, according to any one of claims 1 through 14, wherein the fluorescent pastes used have a viscosity of 0.1 to 50 Pa·s.

[Claim 16] A method for producing a plasma display panel, according to any one of claims 1 through 15, wherein the fluorescent powders used have a cumulative average grain size of 0.5 to 15  $\mu\text{m}$  and a specific surface area of 0.1 to 5  $\text{m}^2/\text{cm}^3$ .

[Claim 17] A method for producing a plasma display panel, according to any one of claims 1 through 16, wherein the coating with the fluorescent pastes is followed by drying, with the fluorescent material coated side turned downward.

[Claim 18] A method for producing a plasma display panel, according to any one of claims 1 through 17, wherein the fluorescent pastes are photosensitive fluorescent pastes.

[Detailed description of the invention]

[Technical field of the invention]

The present invention relates to a new method for producing a plasma display panel. The plasma display panel of the present invention can be used for wall mounted television sets and information displays.

[Prior arts]

In recent years, plasma displays attract attention as large-sized displays. Plastic display panels (PDPs) are increasingly adopted in such areas as office automation apparatuses and official bulletin displays since they allow high speed presentation compared to liquid crystal panels and can be easily produced in larger sizes. They are also expected to be more adopted in such areas as high grade television sets.



Since the application range is expanded like this, color PDPs having many fine display cells to allow highly precise display attract special attention.

One display cell has one pixel composed of three primary colors, i.e., red (R), green (G) and blue (B) of fluorescent materials emitting light by plasma discharge.

Conventionally known methods for producing plasma display panels include screen printing. Especially for forming the fluorescent materials of plasma displays, screen printing is often used.

Japanese Patent Laid-Open (Kokai) No. 6-5205 proposes to use sand blasting after screen printing, and Japanese Patent Laid-Open (Kokai) No. 5-144375 proposes to effect screen printing after coating with a crosslinking agent. Both the techniques use screen printing.

However, screen printing does not allow a highly precise pattern to be formed disadvantageously since the screen is deformed by repeated printing, and also in view of control such as washing of the screen, screen printing cannot be said to be suitable for mass production.

The use of lithography is also practiced as a method for obtaining a highly precise pattern. However, in this case, since the respective fluorescent material layers of red, green and blue must be formed, the respective steps of coating, exposure, development, drying, etc. must be repeated three

times for the colors, and after full face coating with the respective colors and exposure, unnecessary portions must be removed by development, to wastefully consume the fluorescent powders. If they are recovered for reproduction, the cost is raised. Furthermore, there is also a problem that since the full face is coated with the respective colors, the overlying colors can remain after development, to cause color mixing.

It is also proposed to eject a fluorescent paste from the tip of an ink jet nozzle, for forming a fluorescent material layer. However, in the case of ink jet, since the fluorescent paste is ejected by a piezoelectric device, etc., the viscosity of the fluorescent paste must be kept at 0.2 poise or less, and so the amount of the fluorescent powder in the paste cannot be increased. Therefore, the thickness of the formed fluorescent material layer is too thin disadvantageously. There is another problem that since the ink jet nozzle must be small in diameter, it is clogged with the fluorescent powder.

[Problems to be solved by the invention]

The object of the present invention is to provide a method for producing a plasma display panel free from the above disadvantages, particularly a method for producing a plasma display panel which allows fluorescent material layers to be formed simply at high accuracy.

[Means for solving the problems]

The object of the present invention can be achieved by a method for producing a plasma display panel, in which a glass substrate is coated with three fluorescent pastes respectively containing a fluorescent powder emitting light of red, green or blue discharged from a paste applicator with outlet holes, in stripes on the spaces between the respectively adjacent partitions formed on the substrate, and the pastes are burned to form a fluorescent face, characterized in that the number of outlet holes of each paste applicator is in a range of  $16n$  (where  $n$  is a natural number)  $\pm 5$ .

[Embodiments of the invention]

The present invention relates to a method for coating a glass substrate 2 having electrodes 1 and partitions 3 formed on it as shown in Fig. 1, partially with fluorescent pastes, particularly a method for forming a red fluorescent material layer 4, a blue fluorescent material layer 5 and a green fluorescent material layer 6 as shown in Fig. 2, by coating the substrate with fluorescent materials emitting light of any of three principle colors, red, blue and green in stripes.

Since three stripes of red (R), blue (B) and green (G) form one pixel line, they must be formed in repetition of RGB or RBG.

In the production method of the present invention, for example, paste applicators with outlet holes arranged for respective colors of R, G and B; and/or a glass substrate is driven to travel in the direction parallel to the partitions,

to discharge fluorescent pastes onto the spaces formed between the respectively adjacent partitions and predetermined for the respective colors, for coating.

The number of display cells, i.e., the number of pixel lines per display depends on the preciseness desired as a display, the size of the display, etc., but is generally selected from 640, 800, 1024, 1280, 1920, etc. These numbers are mostly multiples of 16.

In the production method of the present invention, the number of outlet holes per paste applicator is in a range of  $16n$  (where  $n$  is a natural number)  $\pm 5$ .

If the number of outlet holes per paste applicator is in said range, any demand for the number of pixel lines per substrate can be satisfied by using one or more paste applicators irrespective of whether or not the number of pixel lines is a multiple of 16. So, efficient coating is assured.

To further improve the accuracy in the thickness of the paste applied per striped space between adjacent partitions and to raise the coating speed, can be used a paste applicator with two or more outlet holes per stripe in the direction parallel to the partitions can be used for simultaneously discharging the fluorescent paste of one color from the plurality of outlet holes for coating (Fig. 8). In this case, it is preferable to use, for example, a paste applicator having two or more outlet holes in one line in the direction parallel to the partitions,

or a paste applicator having outlet holes arranged in two or more lines in the direction perpendicular to the partitions at coating position intervals predetermined for each color and in two or more lines in the direction parallel to the partitions.

Moreover, one paste applicator with outlet holes for discharging two or more fluorescent pastes different in the color of emitted light can also be used. However, in this case, to avoid mixing of colors, it is preferable that the distance between the outlet holes for discharging fluorescent pastes different in color is 600  $\mu\text{m}$  or more. In a highly precise plasma display panel, the partition intervals are 100 to 400  $\mu\text{m}$ . For example, if the outlet holes are kept apart from each other in the direction parallel to the partitions to have a straight distance of 600  $\mu\text{m}$  or more between the respectively adjacent holes, the outlet holes for three colors can be arranged as three consecutively adjacent holes (Fig. 9).

If respectively independent paste applicators are used to discharge fluorescent pastes respectively different in color, they can be driven to travel at the same speed in parallel to the partitions and/or the glass substrate can be driven to travel for coating.

As a more efficient method, if two or more paste applicators respectively for discharging the fluorescent paste emitting light of each color are arranged, or if two or more paste applicators respectively for simultaneously discharging

two or more fluorescent pastes different in the color of emitted light are arranged, and they are synchronized or interlocked to be driven for traveling in the same direction, for coating the full face of the panel (Fig. 10), then the coating time can be one half or less, compared to the case of using one paste applicator for each color.

In this case, it is efficient and preferable that the two or more paste applicators are located apart from each other by integer times each of the partition intervals in the direction perpendicular to the partitions, or that if each of the intervals between the adjacent two or more paste applicators is smaller than the width of each of the paste applicators in the direction perpendicular to the partitions, they are located apart from each other in the direction parallel to the partitions (Fig. 11).

Furthermore, to avoid the mixing of the adjacent fluorescent pastes different in color, it is also preferable to dry after coating of each color.

It is preferable that the inner diameter of the outlet holes used in the present invention is less than each of the partition intervals, i.e., less than 100 to 400  $\mu\text{m}$ , and the inner diameter must be larger than the grain size of the fluorescent powder. It is preferable that the inner diameter is 80 to 400  $\mu\text{m}$  for stable discharge of the fluorescent paste, considering

the grain size distribution of the fluorescent powder and some cohesion.

It is preferable that the outlet holes used in the present invention are nozzles (Fig. 6) or needles (Fig. 7), since the paste applicator is less likely to be contaminated.

Furthermore, it is preferable that during coating, the distance between the tops of the partitions and the tips of the outlet holes of the paste applicator is kept at 0.01 to 2 mm, when the fluorescent pastes are discharged at a constant flow rate for coating the spaces between the respectively adjacent partitions while the paste applicator is driven to travel at a constant speed and/or the glass substrate is driven to travel at a constant speed. A more preferable distance range is 0.03 to 1 mm. If the distance is kept in this range during coating, the fluorescent pastes can be discharged to be poured onto the spaces between the respectively adjacent partitions while their contact with the tops of the partitions is avoided.

It is preferable that the viscosity of the fluorescent pastes used in the present invention is 0.1 to 50 Pa·s. A more preferable range is 0.5 to 40 Pa·s poises.

It is preferable that the fluorescent paste consists of a fluorescent powder, and the ingredients to be evaporated or decomposed to be removed by the drying and burning after coating. In this case, a fluorescent material layer composed of a fluorescent material only can be formed after burning. The

fluorescent paste can be, for example, a composition consisting of a fluorescent powder, organic dispersing agent, water soluble organic binder and water, or a composition consisting of a fluorescent powder, organic binder and organic solvent, or a composition with an organic dispersing agent added to said composition, etc.

If the composition is made photosensitive, patterning by photolithography can be applied. This is effective for removing the fluorescent materials formed on the tops of the partitions and other unnecessary portions than the spaces between the respectively adjacent partitions. The coated substrate is exposed through a photomask, so that the pastes in the exposed portions may be made soluble or insoluble in the developer, and the unnecessary portions are removed in the development step, to form the fluorescent material layers of the respective colors.

The fluorescent powders used in the present invention are not especially limited. For example, those emitting light of red include  $\text{Y}_2\text{O}_3:\text{Eu}$ ,  $\text{YVO}_4:\text{Eu}$ ,  $(\text{Y}, \text{Gd})\text{BO}_3:\text{Eu}$ ,  $\text{Y}_2\text{O}_3\text{S}:\text{Eu}$ ,  $\text{g-Zn}_3(\text{PO}_4)_2:\text{Mn}$ ,  $(\text{ZnCd})\text{S}:\text{Ag}+\text{In}_2\text{O}_3$ , etc. Those emitting light of green include  $\text{Zn}_2\text{GeO}_2:\text{Mn}$ ,  $\text{BaAl}_{12}\text{O}_{19}:\text{Mn}$ ,  $\text{Zn}_2\text{SiO}_4:\text{Mn}$ ,  $\text{LaPO}_4:\text{Tb}$ ,  $\text{ZnS}:\text{Cu}, \text{Al}$ ,  $\text{ZnS}:\text{Au}, \text{Cu}, \text{Al}$ ,  $(\text{ZnCd})\text{S}:\text{Cu}, \text{Al}$ ,  $\text{Zn}_2\text{SiO}_4:\text{Mn}, \text{As}$ ,  $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}$ ,  $\text{CeMgAl}_{11}\text{O}_{19}:\text{Tb}$ ,  $\text{Gd}_2\text{O}_2\text{S}:\text{Tb}$ ,  $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tb}$ ,  $\text{ZnO}:\text{Zn}$ , etc. Those emitting light of blue include  $\text{Sr}_5(\text{PO}_4)_3\text{Cl}:\text{Eu}$ ,



BaMgAl<sub>14</sub>O<sub>23</sub>:Eu, BaMgAl<sub>16</sub>O<sub>27</sub>:Eu, BaMg<sub>2</sub>Al<sub>14</sub>O<sub>24</sub>:Eu, ZnS:Ag+red pigment, Y<sub>2</sub>SiO<sub>3</sub>:Ce, etc.

Furthermore, the present invention allows the use of rare earth element tantalate fluorescent materials in which at least one matrix forming rare earth element selected from yttrium (Y), gadolinium (Gd) and lutetium (Lu) is substituted by at least one element selected from a group consisting of thulium (Tm), terbium (Tb) and europium (Eu). A preferable rare earth element tantalate fluorescent material is europium activated yttrium tantalate represented by composition formula Y<sub>1-x</sub>Eu<sub>x</sub>TaO<sub>4</sub> (where x is approximately 0.005 to 0.1). A preferable red fluorescent material is europium activated yttrium tantalate, and a preferable green fluorescent material is terbium activated yttrium tantalate represented by composition formula Y<sub>1-x</sub>Tb<sub>x</sub>TaO<sub>4</sub> (where x is approximately 0.001 to 0.2). A preferable blue fluorescent material is thulium activated yttrium tantalate represented by Y<sub>1-x</sub>Tb<sub>x</sub>TaO<sub>4</sub> (where x is approximately 0.001 to 0.2).

Further preferable green fluorescent materials include a manganese activated zinc fluorescent material (Zn<sub>2</sub>SiO<sub>4</sub>:Mn) with an average grain size of 2 μm to 8 μm activated by 0.2 wt% to less than 0.1 wt% of manganese based on the weight of zinc silicate (Zn<sub>2</sub>SiO<sub>4</sub>) matrix, and a manganese activated zinc silicate fluorescent material represented by general formula (Zn<sub>1-x</sub>Mn<sub>x</sub>)O·αSiO<sub>2</sub> (where 0.01 ≤ x ≤ 0.2 and 0.5 < α ≤ 1.5).

The grain size of the fluorescent powders used in the above is selected, considering the line width, inter-line space and thickness of the fluorescent material layer pattern to be prepared. It is preferable that the powders are 0.5 to 15  $\mu\text{m}$ , especially 0.5 to 6  $\mu\text{m}$  in cumulative average grain size and 0.1 to 5  $\text{m}^2/\text{g}$  in specific surface area. It is more preferable that the grain size is 1 to 6  $\mu\text{m}$  and that the specific surface area is 0.5 to 4  $\text{m}^2/\text{g}$ . If the grain size and the specific surface area are in these ranges, the clogging of the outlet holes is unlikely to occur, and stable discharge can be effected, to provide a highly precise pattern. Furthermore, the fluorescent materials are higher in luminous efficiency and longer in life preferably. If the grain size is less than 0.5  $\mu\text{m}$  or the specific surface area is more than 5  $\text{m}^2/\text{g}$ , the powders are too fine, and are likely to cohere. In this case, in the patterning according to photolithography, light is scattered during exposure, and non-exposed portions are photoset. So, extra fluorescent materials remain in the non-exposed portions at the time of development, not allowing a highly precise pattern to be obtained. Furthermore, the fluorescent materials decline in luminous efficiency and life.

As for the form of the fluorescent powders, polyhedral grains can be used, but it is preferable that the powders are not cohesive. It is more preferable that the powders are spherical grains since the clogging of the outlet holes is

unlikely to occur, and since stable discharge can be effected and furthermore since the influence of scattering during exposure can be lessened in the case of patterning by photolithography. It is preferable that spherical grains account for 80% or more in the fluorescent powder in the number of grains. It is more preferable that spherical grains account for 90% or more. If spherical grains account for less than 80% in number, it is difficult to obtain a highly precise pattern, because of the influence of scattering by the fluorescent powder at the time of exposure to ultraviolet light. To measure the spherical grain percentage, the fluorescent powder is photographed at 300 times by an optical microscope, and the number of countable grains is counted, to calculate the rate of spherical grains as the spherical grain percentage.

The organic component used in the present invention contains an organic binder, solvent, and, as required, such additives as a dispersing agent, plasticizer and leveling agent.

The organic binders which can be used here include, for example, (poly)vinyl butyral, (poly)vinyl acetate, (poly)vinyl alcohol, cellulose polymers (e.g., methyl cellulose, ethyl cellulose, hydroxyethyl cellulose, methylhydroxyethyl cellulose), polyethylene, silicone polymers (e.g., (poly)methylsiloxane, (poly)methylphenylsiloxane), polystyrene, butadiene/styrene

copolymer, (poly)vinylpyrrolidone, polyamides, high molecular polyesters, ethylene oxide-propylene oxide copolymer, polyacrylamide, and various acrylic polymers (e.g., sodium polyacrylate, (poly) lower alkylacrylates, (poly) lower alkylmethacrylates and various copolymers and multipolymers of lower alkylacrylates and methacrylates.

The plasticizers which can be used here include, for example, dibutyl phthalate, dioctyl phthalate, polyethylene glycol, glycerol, etc.

The solvents which can be used here include, for example, methyl cellosolve, ethyl cellosolve, butyl cellosolve, methyl ethyl ketone, dioxane, acetone, cyclohexanone, cyclopentanone, isobutyl alcohol, isopropyl alcohol, tetrahydrofuran, butylcarbitol acetate, dimethyl sulfoxide,  $\gamma$ -butyrolactone, bromobenzene, chlorobenzene, dibromobenzene, dichlorobenzene, bromobenzoic acid, chlorobenzoic acid and organic solvent mixtures containing at least one or more of the foregoing.

The organic dispersing agents which can be used here include anionic and nonionic surfactants, etc.

In the present invention, when the patterning by photolithography is effected, it is possible to use photosensitive fluorescent pastes respectively with an organic component containing a photosensitive compound and a fluorescent powder as essential ingredients.

It is preferable that the organic component used in the photosensitive fluorescent pastes contains 10 wt% or more of a photosensitive compound. More preferable is 25 wt% or more. The organic component containing a photosensitive compound contains at least one photosensitive ingredient selected from photosensitive polymers, photosensitive monomers and photosensitive oligomers, and furthermore, as required, also such additives as photopolymerization initiator, sensitizer and ultraviolet light absorber.

It is preferable that the amount of the organic component containing a photosensitive compound used in the present invention is 15 to 60 wt%. If less than 15 wt%, the pattern property is degraded due to insufficient sensitivity, and if more than 60 wt%, the removal of the binder by burning is insufficient.

The photosensitive component can be either a light insolubilizable photosensitive component or a light solubilizable photosensitive component. The light insolubilizable photosensitive components which can be used here include the following:

(1) A component which contains one or more functional monomers, oligomers and polymers with one or more unsaturated groups in the molecule

(2) A component which contains a photosensitive compound such as an aromatic diazo compound, aromatic diazide component or

organic halogen compound

(3) A so-called diazo resin such as a condensation product of a diazo based amine and formaldehyde

The light solubilizable photosensitive components which can be used here include the following:

(4) A component which contains a complex of a diazo compound with an inorganic salt or organic acid, or quinonediazo

(5) Naphthoquinone 1,2-diazido-5-sulfonate of phenol or novolak resin, etc. obtained by combining a quinonediazo with a proper polymer binder

As the photosensitive component used in the present invention, any of the above can be used. As the photosensitive component which can be simply used as a mixture with inorganic fine grains, those stated in (1) are preferable.

A photosensitive monomer refers to a compound with a carbon-carbon unsaturated bond. The photosensitive monomers which can be used here include, for example, methyl acrylate, ethyl acrylate, n-propyl acrylate, isopropyl acrylate, n-butyl acrylate, sec-butyl acrylate, iso-butyl acrylate, tert-butyl acrylate, n-pentyl acrylate, allyl acrylate, benzyl acrylate, butoxyethyl acrylate, butoxy triethylene glycol acrylate, cyclohexyl acrylate, dicyclopentanyl acrylate, dicyclopentenyl acrylate, 2-ethylhexyl acrylate, glycerol acrylate, glycidyl acrylate, heptadecafluorodecyl acrylate, 2-hydroxyethyl acrylate, isobornyl acrylate, 2-hydroxypropyl

acrylate, isodecyl acrylate, isooctyl acrylate, lauryl acrylate, 2-methoxyethyl acrylate, methoxy ethylene glycol acrylate, methoxy diethylene glycol acrylate, octafluoropentyl acrylate, phenoxyethyl acrylate, stearyl acrylate, trifluoroethyl acrylate, allylated cyclohexyl diacrylate, 1,4-butanediol diacrylate, 1,3-butylene glycol diacrylate, ethylene glycol diacrylate, diethylene glycol diacrylate, triethylene glycol diacrylate, polyethylene glycol diacrylate, dipentaerythritol hexaacrylate, dipentaerythritol monohydroxypentaacrylate, ditrimethylolpropane tetraacrylate, glycerol diacrylate, methoxylated cyclohexyl diacrylate, neopentyl glycol diacrylate, propylene glycol diacrylate, polypropylene glycol diacrylate, triglycerol diacrylate, trimethylolpropane triacrylate, acrylamide, aminoethyl acrylate, phenyl acrylate, phenoxyethyl acrylate, benzyl acrylate, 1-naphthyl acrylate, 2-naphthyl acrylate, bisphenol A diacrylate, diacrylate of bisphenol A - ethylene oxide addition product, diacrylate of bisphenol A - propylene oxide addition product, thiophenol acrylate, benzylmercaptane acrylate, monomers obtained by substituting the hydrogen atoms of these aromatic rings by 1 to 5 chlorine or bromine atoms, styrene, p-methylstyrene, o-methylstyrene, m-methylstyrene, chlorinated styrene, brominated styrene,  $\alpha$ -methyl styrene, chlorinated  $\alpha$ -methylstyrene, brominated  $\alpha$ -methylstyrene,

chloromethylstyrene, hydroxymethylstyrene, carboxymethylstyrene, vinylnaphthalene, vinylanthracene, vinylcarbazole, compounds obtained by substituting the acrylate in the molecule of each of the above compounds partially or wholly by methacrylate,  $\gamma$ -methacryloxypropyltrimethoxysilane, 1-vinyl-2-pyrrolidone, etc. One or more of these compounds can be used in the present invention.

In addition to the above, the developability after photosensitization can be improved by adding an unsaturated acid such as an unsaturated carboxylic acid. The unsaturated carboxylic acids which can be used here include, for example, acrylic acid, methacrylic acid, itaconic acid, crotonic acid, maleic acid, fumaric acid, vinylacetic acid, their anhydrides, etc.

The binders which can be used here include polyvinyl alcohol, polyvinyl butyral, methacrylate polymers, acrylate polymers, acrylate-methacrylate copolymers,  $\alpha$ -methylstyrene polymer, butyl methacrylate resin, etc.

Furthermore, oligomers and polymers obtained by polymerizing at least one of the above mentioned compounds with a carbon-carbon double bond can also be used.

For polymerization, 10 wt% or more, preferably 35 wt% or more of any of these monomers and another photosensitive monomer can be copolymerized.



As the monomer to be copolymerized, if an unsaturated acid such as an unsaturated carboxylic acid is copolymerized, the developability after sensitizing can be further improved. The unsaturated carboxylic acids which can be used here include, for example, acrylic acid, methacrylic acid, itaconic acid, crotonic acid, maleic acid, fumaric acid, vinylacetic acid, anhydrides of these acids, etc.

It is preferable that the acid value (AV) of the polymer or oligomer with acidic groups such as carboxyl groups in the side chains obtained like this is 50 to 180. A more preferable range is 70 to 140. If the acid value is more than 180, the development allowable range becomes narrow. If the acid value is less than 50, the solubility of non-exposed portions in the developer declines, and if the developer concentration is raised in this case, the exposed portions, too, peel, making it hard to obtain a highly precise pattern.

If photo-reactive groups are added to the side chains or molecular ends of the above polymer or oligomer, it can be used as a photosensitive polymer or photosensitive oligomer.

Preferable photo-reactive groups are ethylenic unsaturated groups which include vinyl groups, allyl groups, acryl groups, methacryl groups, etc.

Such side chains can be added to an oligomer or polymer, by letting an ethylenic unsaturated compound with a glycidyl group or isocyanato group or acrylic acid chloride, methacrylic

acid chloride or allyl chloride addition-react with the mercapto groups, amino groups, hydroxyl groups or carboxyl groups in the polymer.

The ethylenic unsaturated compounds with a glycidyl group which can be used here include glycidyl acrylate, glycidyl methacrylate, allyl glycidyl ether, glycidyl ethylacrylate, crotonyl glycidyl ether, glycidyl crotonate ether, glycidyl isocrotonate ether, etc.

The ethylenic unsaturated compounds with an isocyanato group which can be used here include (meth)acryloyl isocyanate, (meth)acryloylethyl isocyanate, etc.

It is preferable to add an ethylenic unsaturated compound with a glycidyl group or isocyanate, acrylic acid chloride, methacrylic acid chloride or allyl chloride by 0.05 to 1 mole equivalent for each mole equivalent of the mercapto groups, amino groups, hydroxyl groups or carboxyl groups in the polymer.

The photo polymerization initiators which can be used here include, for example, benzophenone, methyl o-benzoylbenzoate, 4,4-bis(dimethylamine)benzophenone, 4,4-bis(diethylamino)benzophenone, 4,4-dichlorobenzophenone, 4-benzoyl-4-methyl diphenyl ketone, dibenzyl ketone, fluorenone, 2,2-diethoxyacetophenone, 2,2-dimethoxy-2-phenyl-2-phenylacetophenone, 2-hydroxy-2-methylpropiophenone, p-t-butylldichloroacetophenone, thioxanthone, 2-methylthioxanthone, 2-chlorothioxanthone, 2-

isopropylthioxanthone, diethylthioxanthone, benzyl, benzyldimethyl ketanol, benzylmethoxyethyl acetal, benzoin, benzoin methyl ether, benzoin butyl ether, anthraquinone, 2-t-butylanthraquinone, 2-amylanthraquinone, fä-chloroanthraquinone, anthrone, benzanthrone, dibenzosuberone, methyleneanthrone, 4-azidobenzalacetophenone, 2,6-bis(p-azidobenzylidene)cyclohexanone, 2,6-bis(p-azidobenzylidene)-4-methylcyclohexanone, 2-phenyl-1,2-butadione-2-(o-methoxycarbonyl)oxime, 1-phenylpropanedione-2-(o-ethoxycarbonyl)oxime, 1,3-diphenylpropanetrione-2-(o-ethoxycarbonyl)oxime, 1-phenyl-3-ethoxypropanetrione-2-(o-benzoyl)oxime, Michler's ketone, 2-methyl-[4-(methylthio)phenyl]-2-morpholino-1-propanone, naphthalenesulfonyl chloride, quinolinesulfonyl chloride, N-phenylthioacridone, 4,4-azobisisobutyronitrile, diphenyl disulfide, benzthiazole disulfide, triphenylphosphine, camphorquinone, carbon tetrabromide, tribromophenylsulfone, benzoyl peroxide and combinations consisting of a photo-reducing dye such as Eösine or Ethylene Blue and a reducing agent such as ascorbic acid or triethanolamine. In the present invention, one or more of them can be used.

The photopolymerization initiator is added by 0.1 to 6 wt% based on the weight of the photosensitive component. A more preferable range is 0.2 to 5 wt%. If the amount of the

polymerization initiator is too small, the sensitivity to light becomes low, and if too large, more exposed portions may remain.

It is also effective to add an ultraviolet light absorber. If an absorber high in ultraviolet light absorbing effect is added, high preciseness and high resolution can be obtained. As the ultraviolet light absorber, an organic dye can be used. Above all, it is preferable to use an organic dye with a high UV absorption coefficient in a wavelength range of 350 to 450 nm. The organic dyes which can be used here include azo dyes, aminoketone dyes, xanthene dyes, quinoline dyes, anthraquinone dyes, benzophenone dyes, diphenylcyanoacrylate dyes, triazine dyes, p-aminobenzoic acid dyes, etc. An organic dye is preferable since it does not remain in the burned insulation film even if it is added as a light absorber and since the decline of the insulation film properties by the light absorber can be decreased. Among the organic dyes, especially azo dyes and benzophenone dyes are preferable. It is preferable that the amount of the organic dye added is 0.05 to 5 wt%. If the amount of the organic dye is less than 0.05 wt%, the effect of adding an ultraviolet light absorber decreases, and if more than 5 wt%, the properties of the burned insulation film decline unpreferably. A more preferable range is 0.15 to 1 wt%. An ultraviolet light absorber comprising an organic dye can be added, for example, by preparing a solution with an organic dye dissolved in an organic solvent, mixing a fluorescent powder

into the organic solvent, and drying. According to this method, capsules with the surfaces of individual grains of the fluorescent powder coated with an organic film can be produced.

A sensitizer is added to improve the sensitivity. The sensitizers which can be used here include, for example, 2,4-diethylthioxanthone, isopropylthioxanthone, 2,3-bis(4-diethylaminobenzal)cyclopentanone, 2,6-bis(4-dimethylaminobenzal)cyclohexanone, 2,6-bis(4-dimethylaminobenzal)-4-methylcyclohexanone, Michler's ketone, 4,4-bis(diethylamino)-benzophenone, 4,4-bis(dimethylamino)chalcone, 4,4-bis(diethylamino)chalcone, p-dimethylaminocinnamylideneindanone, p-dimethylaminobenzylideneindanone, 2-(p-dimethylaminophenylvinylene)-isonaphthothiazole, 1,3-bis(4-dimethylaminobenzal)acetone, 1,3-carbonyl-bis(4-diethylaminobenzal)acetone, 3,3-carbonyl-bis(7-diethylaminocoumarin), N-phenyl-N-ethylethanolamine, N-phenylethanolamine, N-tolyldiethanolamine, N-phenylethanolamine, isoamyl dimethylaminobenzoate, isoamyl diethylaminobenzoate, 3-phenyl-5-benzoylthiotetrazole, 1-phenyl-5-ethoxycarbonylthiotetrazole, etc. In the present invention, one or more of them can be used. Among sensitizers, some can be used also as photo polymerization initiators. When a sensitizer is added to the photosensitive paste of the present invention, the amount is usually 0.05 to 10 wt% based on the

amount of the photosensitive component. A preferable range is 0.1 to 10 wt%. If the amount of the sensitizer is too small, the effect of improving the photosensitivity cannot be manifested, and if too large, the exposed portion remaining rate may become too small.

The fluorescent paste or photosensitive fluorescent paste consisting of these ingredients is usually prepared by mixing various ingredients such as a fluorescent powder, organic binder, ultraviolet light absorber, photosensitive polymer, photosensitive monomer, photopolymerization initiator, dispersing agent, plasticizer and solvent to achieve a predetermined composition, and homogeneously dispersing the mixture by a three-roller mill or kneader. As other methods, a dispersing agent dissolved in a solvent can be mixed with the other ingredients, or a fluorescent powder treated on the surfaces of its grains by a dispersing agent or ultraviolet light absorber can also be mixed with the other ingredients.

The fluorescent materials of the plasma display must have a thickness of 10 to 50  $\mu\text{m}$  on the bottoms of the spaces between the respectively adjacent partitions and along the lateral sides (as a thickness measured at a half-height position of each partition), and the coating thickness must be controlled, considering the shrinkage after drying and burning depending on the fluorescent powder content of each fluorescent paste used.

The glass substrate used in the present invention is not especially limited, and a general soda lime glass or a glass obtained by annealing a soda lime glass, or a glass with a high strain point (e.g., "PD-200" produced by Asahi Glass Co., Ltd.), etc. can be used. The size of the glass substrate is not especially limited, and a 1 to 5 mm thick glass can be used.

By forming fluorescent material layers on a glass substrate with electrodes and partitions formed on it, a board for a plasma display can be obtained. A substrate with a dielectric layer formed on it in addition to electrodes and partitions can also be used. The electrodes can be formed by applying silver, aluminum, copper, gold, nickel, tin oxide or ITO, etc. by screen printing or using a photosensitive conductive paste.

The partitions can be formed as a grid or in stripes, but the present invention is especially effective when the partitions are formed in stripes. It is preferable that the pitch of the partitions is 100 to 500  $\mu\text{m}$ , and that the height of the partitions is 50 to 200  $\mu\text{m}$ .

In the present invention, in the heating step to dry the pastes applied by a paste applicator with outlet holes or nozzles or needles on the spaces formed between the respectively adjacent partitions, it is preferable to hold the glass substrate, with the fluorescent material coated side turned downward. The fluorescent pastes move along the lateral sides

of the partitions, to form the fluorescent material layers also along the lateral sides of the partitions. If the fluorescent material layers are formed not only on the spaces between the respectively adjacent partitions but also along the lateral sides of the partitions, the area of the fluorescent material face can be increased effectively for enhancing the luminance of the plasma display. In this case, it is preferable to ensure that the angle formed between the glass substrate and the horizontal plane is 0 to 30 degrees. The drying temperature and time depend on the paste compositions and viscosities, but it is preferable to dry at 50 to 200°C for 5 to 60 minutes.

Furthermore, if photosensitive fluorescent pastes are used in the coating step for patterning by photolithography, coating is followed by exposure and development.

The exposure and development are intended to expose the coated substrate through a photomask for making the exposed portions soluble or insoluble in the developer, and to remove unnecessary portions in the development step.

The exposure method is not especially limited. As in ordinary photolithography, it is general to effect mask exposure using a photomask. Either a negative or positive mask is selected, depending on the photosensitive organic component used. As another method, a laser beam, etc. can also be used for direct drawing without using any photomask. As the exposure



machine, a stepper exposure machine or proximity exposure machine, etc. can be used.

For exposing a large area, after the substrate such as a glass substrate has been coated with photosensitive pastes, the substrate can be carried forward during exposure, to expose a large area by an exposure machine with a small effective exposure area.

The active light used in this case can be visible light, near ultraviolet light, ultraviolet light, electron beam, X ray or laser beam, etc. Among them, ultraviolet light is preferable. The light source can be, for example, a low pressure mercury lamp, high pressure mercury lamp, extra-high pressure mercury lamp, halogen lamp or germicidal lamp, etc. Among them, an extra-high pressure mercury lamp is suitable.

If a photomask is used, the design of the pattern width is important. Usually, a width equal to the space obtained by subtracting the partition width from the partition pitch is used, but considering the accuracy of alignment and the light scattering at the time of exposure, a photomask with a pattern width more narrow than the space by 0 to 30 mm can also be used.

Furthermore, after exposure, a developer is used for development. In this case, immersion, spray or brushing, etc. can be used.

The developer can be an organic solvent which allows the organic component in the photosensitive pastes to be dissolved.

The organic solvent can also contain water to such an extent that the dissolving power may not be lost. If a compound with an acidic group such as a carboxyl group exists in the photosensitive paste, an alkali aqueous solution can be used for development. The alkali aqueous solution can be an alkali metal aqueous solution such as sodium hydroxide or calcium hydroxide aqueous solution, but the use of an organic alkali aqueous solution is preferable since the alkali component can be easily removed at the time of burning.

The organic alkali can be an amine compound. The organic alkalis which can be used here include tetramethylammonium hydroxide, trimethylbenzylammonium hydroxide, monoethanolamine, diethanolamine, etc. The concentration of the alkali aqueous solution is usually 0.01 to 10 wt%, preferably 0.1 to 5 wt%. If the alkali concentration is too low, the non-exposed portions cannot be removed, and if too high, the pattern may peel to erode the exposed portions. In view of process control, it is preferable that the development temperature is 20 to 50°C.

In addition to the above steps, a heating step of 50 to 300°C can also be used for drying or preliminary reaction.

In the present invention, to remove the binder, etc. other than the fluorescent materials, burning in a burning furnace is further effected. The burning atmosphere and temperature depend on the pastes and substrate used, and it is preferable

that the burning is effected in an atmosphere of air, nitrogen or hydrogen, etc. at 400 to 550°C. The burning furnace used can be a known burning furnace such as a batch burning furnace or a belt type or roller-hearth type continuous burning furnace.

According to the above steps, a rear board for a plasma display panel with fluorescent material layers formed on the spaces between the respectively adjacent partitions on a glass substrate can be produced.

If the rear board for a plasma display panel obtained as described above (Fig. 3) is sealed with the glass substrates on the front and rear faces, and a rare gas such as helium, neon or xenon is introduced into the sealed housing, then the panel of a plasma display can be produced. Furthermore, if a driver IC is mounted, a plasma display can be produced.

#### [Examples]

The present invention is described below concretely in reference to examples, but is not limited thereto or thereby. In the examples, each concentration (%) is wt% unless otherwise stated.

#### Example 1

Fluorescent pastes respectively consisting of 47 g of a fluorescent powder, 20 g of a binder polymer (methyl methacrylate-methacrylic acid-styrene copolymer) and 33 g of a solvent ( $\gamma$ -butyrolactone) were prepared. The fluorescent powders used were red (Y, Gd, Eu)BO<sub>3</sub> (cumulative average grain

size  $2.7\ \mu\text{m}$ , specific surface area  $3.1\ \text{m}^2/\text{cc}$ ), green ( $\text{Zn, Mn}_2\text{SiO}_4$  (cumulative average grain size  $3.6\ \mu\text{m}$ , specific surface area  $2.5\ \text{m}^2/\text{cc}$ ) and blue ( $\text{Ba, Eu}\text{MgAl}_{10}\text{O}_{17}$  (cumulative average grain size  $3.7\ \mu\text{m}$ , specific surface area  $2.3\ \text{m}^2/\text{cc}$ ). At first the respective organic ingredients were dissolved by heating at  $60^\circ\text{C}$ , and then a fluorescent powder was added. The mixture was kneaded by a kneader, to prepare a paste. The respective pastes were 12 Pa.s in viscosity.

A glass substrate with nine hundred and sixty one  $150\ \mu\text{m}$  high  $60\ \mu\text{m}$  wide partitions formed at a pitch of  $220\ \mu\text{m}$  was coated with the respective pastes of red, green and blue in stripes.

For coating, paste applicators respectively having sixteen nozzles with an inner diameter of  $150\ \mu\text{m}$  were used. One each paste applicator was used for the fluorescent pastes of red, blue and green. The distance between the tips of the nozzles and the tops of the partitions was set at  $50\ \mu\text{m}$ . The discharge pressure was set at  $3\ \text{kg}/\text{cm}^2$  by a dispenser, and the paste applicators were driven to travel at a constant speed in parallel to the partitions, to discharge the fluorescent pastes at a constant rate for coating the spaces between adjacent partitions. At first, the red fluorescent paste was applied to predetermined spaces between adjacent spaces. In this case, after completion of first time coating (16 spaces), the paste applicator was moved from the end position in the direction perpendicular to the partitions by  $10,560\ \mu\text{m}$ , and it was driven

to travel in the direction reverse to that for first time coating, for second time coating. This was repeated 20 times to coat 320 predetermined spaces with the red fluorescent material. After completion of coating with the red fluorescent material, it was dried at 80°C for 40 minutes with the coated side turned upward. Then, the blue fluorescent paste was similarly applied to the 320 spaces adjacent to those coated with the red fluorescent material and dried. Furthermore, the green fluorescent paste was applied similarly to the 320 spaces adjacent to those coated with the blue fluorescent material and dried. The obtained glass substrate was burned at 500°C for 30 minutes.

The thicknesses of the fluorescent material layers along the lateral sides and on the bottoms of the spaces were observed by an electron microscope. It was found that the respective fluorescent materials were formed with a thickness of  $20 \pm 5$   $\mu\text{m}$  along the lateral sides and with a thickness of  $20 \pm 5$   $\mu\text{m}$  on the bottom of the spaces in stripes.

#### Example 2

Fluorescent pastes respectively consisting of 39 g of a fluorescent powder, 8 g of a binder polymer (ethyl cellulose) and 53 g of a solvent (terpineol) were prepared. The fluorescent powders used were the same red  $(\text{Y, Gd, Eu})\text{BO}_3$ , green  $(\text{Zn, Mn})_2\text{SiO}_4$  and blue  $(\text{Ba, Eu})\text{MgAl}_{10}\text{O}_{17}$  as used in Example 1. At first the respective organic ingredients were dissolved by

heating at 60°C, and then a fluorescent powder was added. The mixture was kneaded by a kneader, to prepare a paste. The respective pastes were 35 Pa·s in viscosity.

A glass substrate with nine hundred and sixty one 150  $\mu\text{m}$  high 60  $\mu\text{m}$  wide partitions formed at a pitch of 220  $\mu\text{m}$  on it was coated with the respective pastes of red, green and blue in stripes.

For coating, paste applicators respectively having twenty outlet holes with an inner diameter of 100  $\mu\text{m}$  formed at a pitch of 660  $\mu\text{m}$  in one line were used. Two paste applicators each were used for the fluorescent pastes of red, blue and green. The distance between the tips of the outlet holes and the tops of the partitions was set at 80  $\mu\text{m}$ . The discharge pressure was set at 4 kg/cm<sup>2</sup> by a dispenser. The paste applicators were driven to travel at a constant speed in parallel to the partitions, while the fluorescent pastes were discharged from twenty outlet holes at a constant rate for coating twenty spaces between adjacent partitions respectively simultaneously. At first, the red fluorescent paste was applied to predetermined spaces between adjacent partitions. In this case, the two paste applicators for discharging the red fluorescent paste were set with the respectively twenty outlet holes arranged in the direction perpendicular to the partitions at the end of the partitions on one side and with the center distance between the outlet holes of the two paste applicators kept at 105.6 mm. The

two paste applicators were synchronized to be driven for traveling simultaneously at the same speed in the same direction. At the position where the coating of respective twenty spaces by the two paste applicators was completed, the two paste applicators were moved in the direction perpendicular to the partitions by 13200  $\mu\text{m}$  simultaneously in the same direction. Then, they were driven to travel similarly in the reverse direction for coating respective twenty spaces between adjacent partitions. This was repeated 8 times to coat predetermined 320 spaces with the red fluorescent material. After completion of coating with the red fluorescent material, it was dried at 80°C for 40 minutes with the coated side turned downward. Then, the blue fluorescent paste was similarly applied by two paste applicators to the 320 spaces adjacent to those coated with the red fluorescent paste and dried. Furthermore, the green fluorescent paste was similarly applied by two paste applicators to the 320 spaces adjacent to those coated with the blue fluorescent paste and dried. The obtained glass substrate was burned at 500°C for 30 minutes.

The thicknesses of the fluorescent material layers formed along the lateral sides and on the bottoms of the spaces were observed by an electron microscope. It was found that the fluorescent materials of the respective colors were formed with a thickness of  $20 \pm 5 \mu\text{m}$  along the lateral sides and with a thickness of  $20 \pm 5 \mu\text{m}$  on the bottoms of the spaces in stripes.

### Example 3

The same fluorescent pastes as used in Example 2 were used for coating the spaces between the respectively adjacent partitions in stripes of red, blue and green as described in Example 2.

For coating, used were paste applicators respectively having 6 mm long needles with an inner diameter of  $150\text{ }\mu\text{m}$  arranged in 80 lines in the direction parallel to the partitions at a pitch of  $660\text{ }\mu\text{m}$  and in 3 lines in the direction perpendicular to the partitions at a pitch of  $650\text{ }\mu\text{m}$  (240 needles in total). Four paste applicators each were used for the fluorescent pastes of red, blue and green. The distance between the tips of the needles of each paste applicator and the tops of the partitions was set at  $80\text{ }\mu\text{m}$ . The discharge pressure was set at  $4\text{ kg/cm}^2$  by a dispenser. The paste applicators were driven to travel in the direction parallel to the partitions at a constant speed, for discharging the fluorescent pastes from 240 outlet holes respectively for coating eighty spaces between adjacent partitions respectively simultaneously. At first, the red fluorescent paste was applied to predetermined spaces between adjacent partitions. In this case, the four paste applicators for discharging the red fluorescent paste were set in such a manner that the needles of each paste applicator might be arranged in 80 lines in the direction parallel to the partitions and in 3 lines in the direction perpendicular to the partitions



and that the respectively adjacent paste applicators might be positioned alternately zigzag in the direction perpendicular to the partitions with a clearance of 1 mm kept between them lest they should contact each other. The four paste applicators were synchronized to be driven for traveling simultaneously at the same speed in the same direction. The discharge of the fluorescent pastes was started and terminated only when the tips of the needles were located above the partitions. In this way, 320 spaces between adjacent partitions were coated with the red fluorescent paste at a time. After completion of coating with the red fluorescent paste, it was dried at 80°C for 40 minutes, with the coated side turned downward. Then, the blue fluorescent paste was similarly applied by four paste applicators to the 320 spaces adjacent to those coated with the red fluorescent paste and dried. Furthermore, the green fluorescent paste was similarly applied by four paste applicators to the 320 spaces adjacent to those coated with the blue fluorescent paste and dried. The obtained glass substrate was burned at 500°C for 30 minutes.

The thicknesses of the fluorescent material layers formed along the lateral sides and on the bottoms of the spaces were observed by an electron microscope. It was found that the fluorescent materials of the respective colors were formed with a thickness of  $20 \pm 5 \mu\text{m}$  along the lateral sides and with a thickness of  $20 \pm 5 \mu\text{m}$  on the bottoms of the spaces in stripes.

#### Example 4

Fluorescent pastes respectively consisting of 45 g of a fluorescent powder, 18 g of a binder polymer (methyl methacrylate-methacrylic acid-styrene copolymer), 11 g of trimethylolpropane triacrylate, 24 g of a solvent ( $\gamma$ -butyrolactone), 2 g of a dispersing agent, 0.05 g of a benzophenone dye and a photopolymerization initiator ("Irgacure" 907, produced by Ciba Geigy) were prepared. The fluorescent powders used were the same red (Y, Gd, Eu)BO<sub>3</sub>, green (Zn, Mn)<sub>2</sub>SiO<sub>4</sub> and blue (Ba, Eu)MgAl<sub>10</sub>O<sub>17</sub> as in Example 1. At first the respective organic ingredients were dissolved by heating at 60°C, and then a fluorescent powder was added. The mixture was kneaded by a kneader, to prepare a paste. The respective pastes were 3.5 Pa·s in viscosity.

The respective pastes were applied to the spaces between the respectively adjacent partitions as described in Example 1, for coating in red, green and blue in stripes.

For coating, used were four paste applicators respectively having 3 mm long needles with an inner diameter of 150  $\mu$ m pressed in at the tip in 80 lines in the direction parallel to the partitions at a pitch of 660  $\mu$ m and in 3 lines in the direction perpendicular to the partitions with the respective 80 outlet holes shifted line by line (at a pitch of 220  $\mu$ m in the direction parallel to the partitions and at a pitch of 15 mm in the direction perpendicular to the partitions) (240 needles in

total). The distance between the tips of the needles of each paste applicator and the tops of the partitions was set at 50  $\mu\text{m}$ . The discharge pressure was set at 3 kg/cm<sup>2</sup> by a dispenser. The paste applicators were driven to travel in parallel to the partitions at a constant speed, while the fluorescent pastes were discharged from 240 holes each at a constant rate for simultaneously coating 240 spaces between respectively adjacent partitions. From the needles of the first line in the direction perpendicular to the partitions of the paste applicator, the red fluorescent paste was discharged onto the predetermined spaces; from the needles of the second line, the green fluorescent paste was discharged; and from the needles of the third line, the blue fluorescent paste was discharged. In this case, the four paste applicators respectively having 80 needles per line in the direction parallel to the partitions and having 3 needles per line in the direction perpendicular to the partitions were positioned alternately zigzag in the direction perpendicular to the partitions with a clearance of 1 mm kept between the adjacent paste applicators lest they should contact each other. The four paste applicators were synchronized to be driven for traveling simultaneously at the same speed in the same direction. The discharge of the fluorescent pastes was started and terminated only when the tips of the needles were located above the partitions. Thus, 960 spaces were coated at a time. After completion of coating, the

coated substrate was dried at 80°C for 40 minutes with the coated side turned downward.

A negative photomask with 70  $\mu\text{m}$  wide lines formed at a pitch of 220  $\mu\text{m}$  was aligned, and the coated substrate was exposed, developed by 0.5% sodium carbonate aqueous solution and burned at 500°C for 30 minutes.

The thicknesses of the fluorescent material layers formed along the lateral sides and on the bottoms of the spaces were observed by an electron microscope. It was found that the fluorescent materials of the respective colors were formed with a thickness of  $23 \pm 2 \mu\text{m}$  along the lateral sides and with a thickness of  $30 \pm 6 \mu\text{m}$  on the bottoms of the spaces in stripes.

[Effects of the invention]

The present invention allows fluorescent material layers of a plasma display to be simply, easily and efficiently formed. Furthermore, fluorescent material layers suitable for a highly precise plasma display can be formed.

[Brief description of the drawings]

[Fig. 1] A typical view showing a glass substrate with partitions formed on it, used in the present invention.

[Fig. 2] A typical view showing a plasma display panel coated with fluorescent material layers according to the method of the present invention.

[Fig. 3] A typical view showing a burned plasma display panel of the present invention.

[Fig. 4] A drawing typically showing an example of the method of the present invention applied to a glass substrate with partitions formed.

[Fig. 5] A schematic sectional view typically showing an example of the paste applicator of the present invention.

[Fig. 6] A schematic sectional view typically showing an example of the paste applicator with nozzles of the present invention.

[Fig. 7] A schematic sectional view typically showing an example of the paste applicator with needles of the present invention.

[Fig. 8] A schematic plan view typically showing an example of the outlet hole arrangement of the paste applicator of the present invention, in relation with the partitions on the glass substrate.

[Fig. 9] A schematic plan view typically showing another example of the outlet hole arrangement of the paste applicator of the present invention, in relation with the partitions on the glass substrate.

[Fig. 10] A schematic plan view typically showing the traveling directions of two paste applicators with outlet holes (or nozzles or needles) synchronized to fully coat the face of the glass substrate with partitions formed on it, as an example of the method of the present invention.

[Fig. 11] A schematic plan view showing the actions of four paste applicators with outlet holes (or nozzles or needles), which are installed alternately zigzag in the direction perpendicular

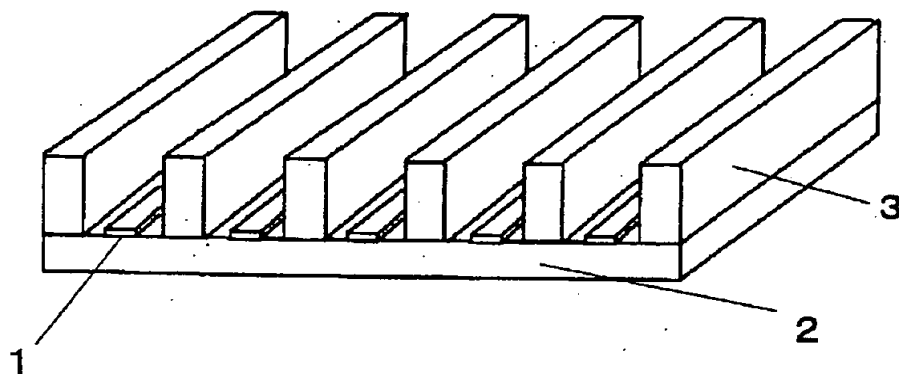
to the partitions lest adjacent paste applicators should contact each other, and synchronized to be driven for traveling simultaneously at the same speed in the same direction, for coating the full face of the glass substrate with partitions formed on it.

[Meanings of symbols]

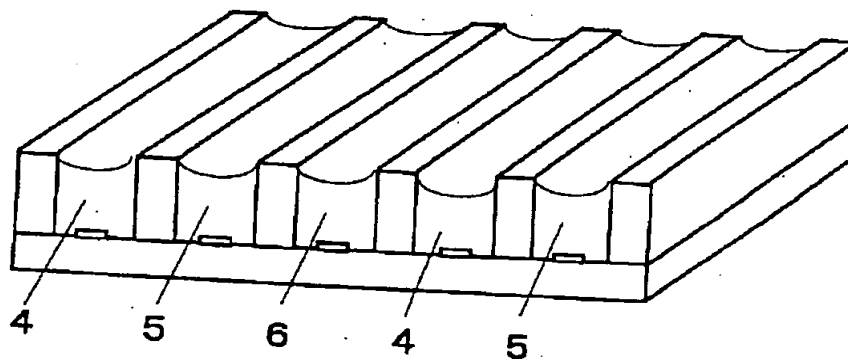
- 1 : electrode
- 2 : glass substrate
- 3 : partition
- 4 : red fluorescent material layer
- 5 : blue fluorescent material layer
- 6 : green fluorescent material layer
- 7 : needle
- 8 : fluorescent paste
- 9 : distance between tip of outlet hole and top of partition
- 10 : paste applicator with outlet holes
- 11 : paste applicator with nozzles
- 12 : paste applicator with needles
- 13 : paste applicator with outlet holes or nozzles or needles arranged in three lines for coating of one color
- 14 : paste applicator with outlet holes or nozzles or needles arranged in three lines for coating of three colors
- 15 : partition on glass substrate
- 16 : traveling direction of paste applicator with outlet holes or nozzles or needles

- 17 : glass substrate with partitions formed on it
- 18 : paste applicator with outlet holes or nozzles or needles
- 19 : traveling direction of synchronized paste applicators  
with outlet holes or nozzles or needles

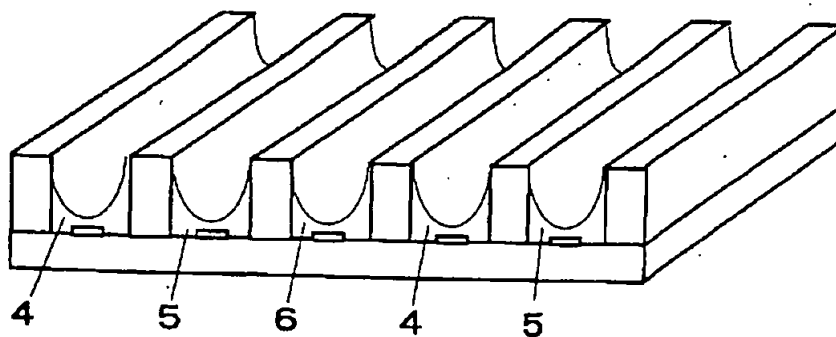
【Fig. 1】



【Fig. 2】

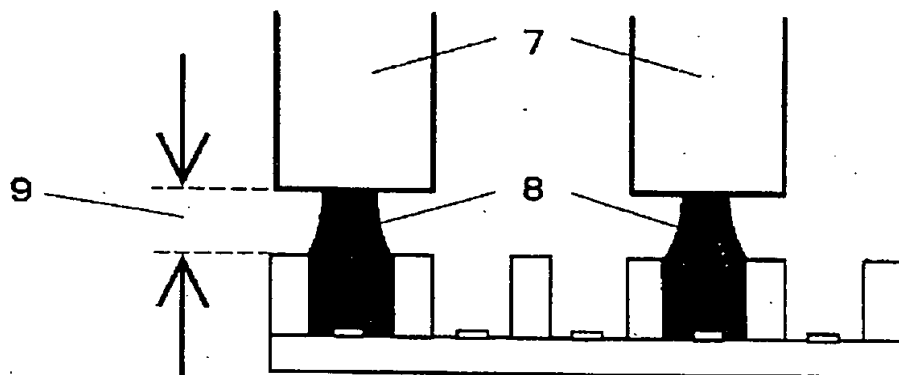


【Fig. 3】





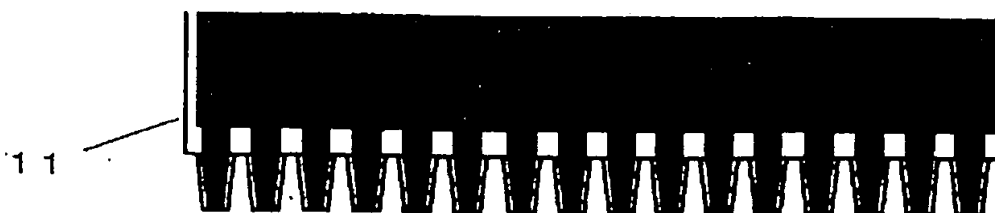
【Fig. 4】



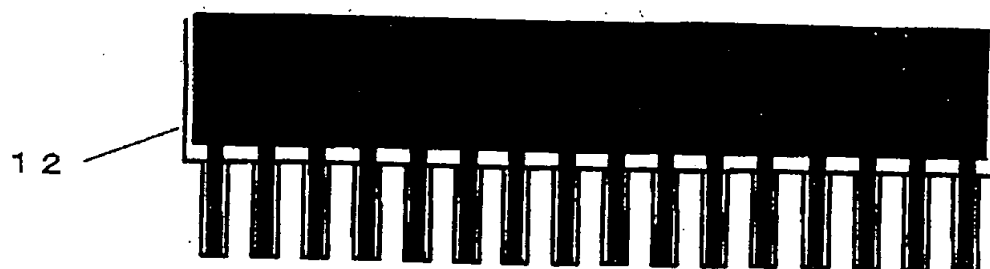
【Fig. 5】



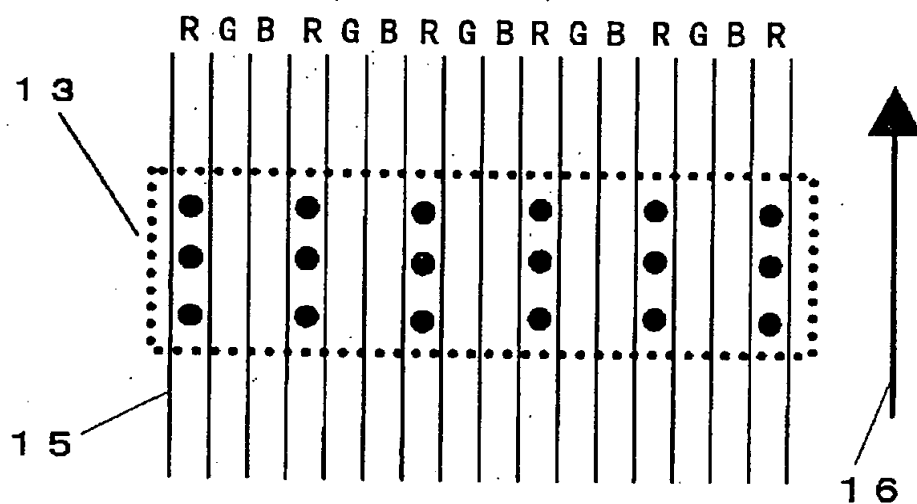
【Fig. 6】



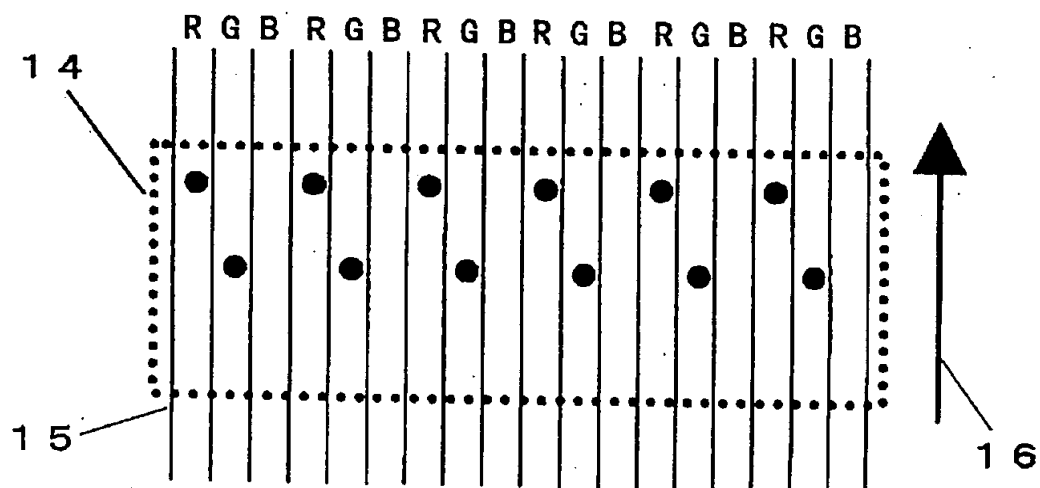
【Fig. 7】



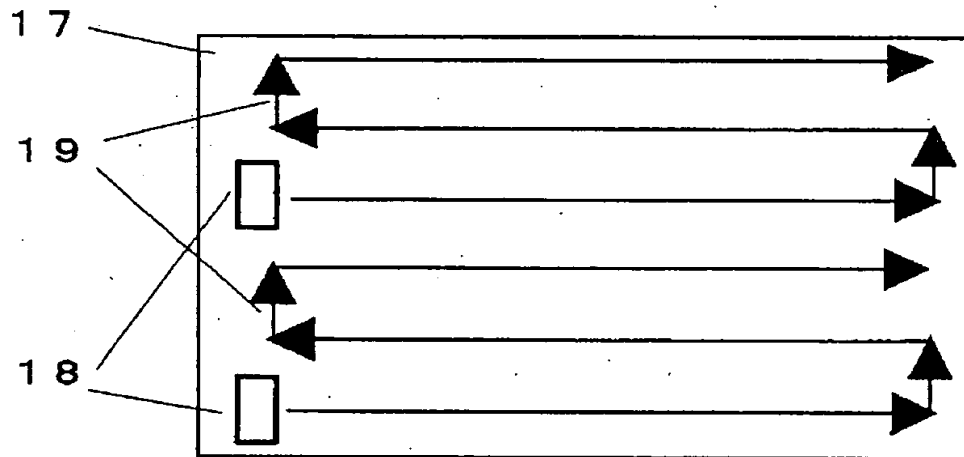
【Fig. 8】



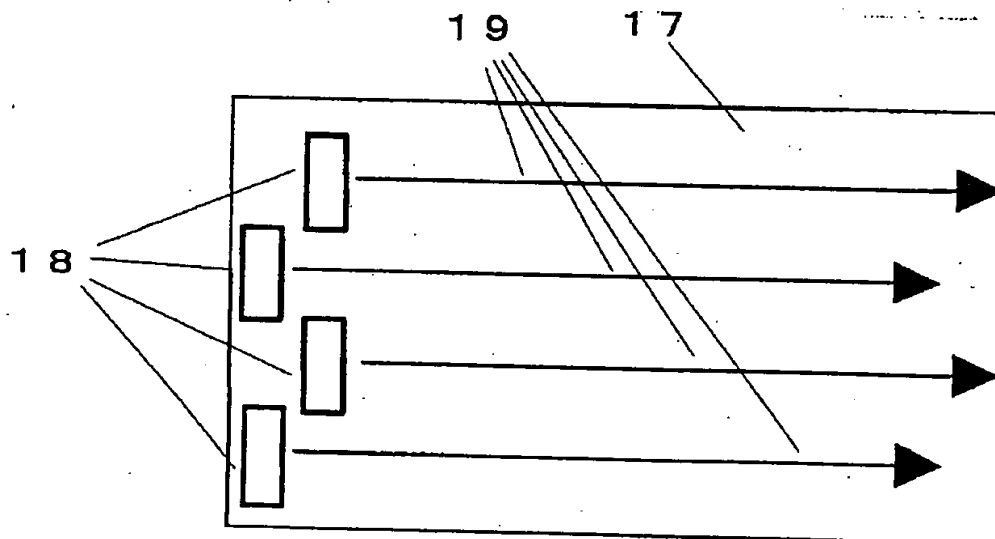
【Fig. 9】



【Fig. 1 0】



【Fig. 1 1】



[Title of the document] Abstract

[Problem] To provide a method for producing a plasma display panel which allows fluorescent material layers to be simply and efficiently formed.

[Solving means] Three fluorescent pastes respectively containing any of red, green and blue fluorescent powders are applied to the spaces between the respectively adjacent partitions predetermined for the respective colors on a glass substrate, and burned to form fluorescent material layers. In this case, the object can be achieved by a method of producing a plasma display panel, characterized in that the number of outlet holes per paste applicator is in a range of  $16n$  (a multiple of 16)  $\pm 5$ .

[Selected drawing] Nil